

SECTION 5 - COST ASSESSMENT

5.0 INTRODUCTION

This section summarizes the most favorable and cost-effective arsenic removal technologies for the 473 impacted POEs operated by water systems with 10,000 or fewer customers in Arizona. An evaluation of all of the technologies and configuration options presented in Section 4 was performed to determine the most appropriate and lowest cost options. Costs were computed for each existing POE or wellhead that requires treatment. A feasibility assessment of blending, centralized treatment (where multiple POEs would be combined together with new pipelines), and use of POU devices was also performed to determine which systems should further consider these options. If these or other non-treatment options are more cost-effective for a particular system, they may choose these options on a case by case basis. For the purposes of the Arizona AMP in identifying funding needs on a Statewide basis, it was assumed that treatment at the existing POE was the selected option.

The system infrastructure information, largely obtained from a Statewide survey, was used to assess the costs and feasibility of the treatment alternatives discussed in Section 4 using the methodology described herein. A feasibility assessment and cost comparison was performed to determine the optimal treatment technology for each system. Systems with water quality characteristics that will likely interfere with arsenic treatment efficiency were also identified and recommendations were provided for appropriate technologies to address these concerns. An overall cost evaluation was performed to determine total treatment costs on a Statewide basis, taking into consideration system size and the least cost option.

5.1 SYSTEM CONFIGURATION INFORMATION

The list of systems and POEs affected, POE flow rate, and water system infrastructure characteristics is presented in Table 5.1. Water quality parameters, including arsenic concentrations and water quality profile symbols, are also presented in the table. The availability of an on-site storage tank at the POE site is indicated by '1' in the table. Availability of additional land for constructing a new storage tank at the POE site is also indicated by '1' in the table. The possibility of partial stream treatment was evaluated and the design flow for partial stream treatment was determined for those POEs with flows of at least 0.5 MGD. Based on information from the ADEQ drinking water database and the survey responses, it appears that current facility configuration and infrastructure information is available for 349 of the 473 impacted POEs. POE flow data and operating information is not available for 124 systems, as shown in Table 5.2. It is recommended that these systems be contacted by the ADEQ Workgroup to obtain the missing flow and facility configuration data.

The following assumptions were made in determining flow rates for these POEs with insufficient data:

- The percent time of operation of the wells was assumed to be 50% wherever this information was not available.
- For systems serving an average population of <500, it was assumed that all the water

was supplied by one POE with a peak flow rate in proportion to the system's population. The flow rate was estimated based on the population served, an average day demand of 150 gallons per capita per day (gpcd) and a peak day factor of 2.0 (0.15 mgd POE flow rate maximum).

- For systems serving greater than 500 persons up to 3,300 persons, it was assumed that the system was served by two POEs with the same demand and peaking factors listed above (0.5 mgd maximum POE flow rate).
- For systems over 3,300 persons up to 10,000 persons, it was assumed that the system was served by 3 POEs using the same demand and peaking factors listed above (1.0 mgd maximum POE flow rate).

5.2 TECHNOLOGY FEASIBILITY ASSESSMENT

Based on the average arsenic concentration, the POE flow rate, availability of an on-site storage tank or additional land for constructing a new storage tank, possibility of partial stream treatment and other variables, the feasibility of the various treatment alternatives was evaluated on an individual POE basis. The following decision analysis methodology was used to determine the feasibility (yes or no) of each treatment configuration. Since the feasibility analysis uses a binary approach, a “no” answer in any category would render that alternative infeasible.

- Feasibility of using single vessel treatment based on raw water arsenic levels <15 ppb - Alternatives 1a, 1b, 2a, and 2b are only feasible if raw water arsenic levels are at or below 15 ppb.
- Feasibility of partial stream treatment - Alternatives 3c, 3d, 3e, 4c, 4d, and 4e are infeasible for small POEs with flows <0.5 mgd due to complex controls and additional costs for piping and flow splitting. These alternatives are also infeasible if the influent arsenic concentration is greater than 20 ppb.
- Feasibility of installing additional tanks for partial stream treatment - Alternatives 3c and 4c are not feasible where sufficient land is not available to construct a new clearwell that is necessary for partial stream treatment.
- Feasibility of CF treatment technology - Alternatives 5a and 5b are not feasible unless the flow is at least 1 mgd and sufficient land area is available.
- Feasibility of POU treatment - not feasible unless the system size is less than 100 connections (300 persons served).

5.2.1 Feasibility Based on Competing Contaminants

The interference of pH and other co-occurring ions, such as fluoride, silica and phosphorus, with arsenic removal are indicated in Table 5.3. Source water containing fluoride levels >2 mg/L or silica levels >50 mg/L can interfere with treatment in an Fe-AA column. Systems affected by high fluoride or silica levels should not use Fe-AA as a treatment alternative (Alternatives 1a, 1b, 3a, 3b, 3c, 3d). Similarly, source water having pH >8.0 or phosphorus levels >0.2 mg/L can interfere with treatment in a granular iron media column. Systems affected by high pH or phosphate levels cannot use granular iron media as an effective treatment alternative (Alternatives 2a, 2b, 4a, 4b, 4c, 4d). Systems that should not consider Fe-AA or granular iron media as treatment alternatives were

discussed in Section 3. If a system has higher pH levels, with phosphorus <0.2 mg/L, granular iron media can be used with pH reduction to 7.5 or lower, provided these costs are lower than the cost for Fe-AA treatment. This comparison and the use of granular iron media with pH adjustment is a site specific evaluation, and for master planning purposes, it was assumed that all systems with pH levels greater than 8 will use Fe-AA since pH adjustment is required in any event.

Limited data for iron and manganese was available in performing the above analyses. These contaminants could also pose significant interferences with adsorption systems, due to oxidation of these compounds into insoluble species that could plug the media. Additional monitoring data will be requested from ADEQ to further evaluate the impacts of iron and manganese, either through the existing databases or through new data obtained from the MAP program in upcoming sampling events.

Based on the conditions identified above, the costs for all the feasible treatment alternatives, as discussed in the previous sections, were determined on a state-wide basis. The feasibility of each treatment alternative is indicated by (Y/N) in Table 5.3.

5.3 COST EVALUATION ON A STATE-WIDE BASIS

The treatment costs (capital and O&M) for the feasible treatment alternatives were calculated using the cost equations developed in the earlier sections. For each impacted POE, capital and O&M costs were calculated for each of the feasible treatment alternatives, as shown in the Appendix Table A-1. From the feasible options, the two lowest cost options, from an annualized cost perspective (annualized costs = capital costs amortized over 20 years at a 6% differential interest rate + and annual O&M costs) were selected for each POE. The total statewide annualized costs of the lowest cost option that are feasible are \$23,800,000. The total capital costs for the lowest cost option, for the entire State, for systems serving less than 10,000 persons are \$109,700,000. The annual O&M costs for the lowest cost option are \$14,200,000. The total state-wide annualized costs of the second lowest cost option that is feasible are \$32,700,000. The total capital costs for the entire State, for systems serving less than 10,000 persons are \$104,600,000 for the second lowest cost option. The annual O&M costs for the second lowest cost option are \$23,800,000. These estimates do not consider engineering fees to design these facilities. For small systems, engineering fees typically range from 25 to 40 percent of the total construction cost. For these future arsenic treatment facilities, a 30% factor was utilized to estimate engineering fees, which results in a state-wide capital project cost of \$142,400,000. A list of the lowest and second lowest cost options for each impacted system is shown in Table 5.4, along with the estimated monthly rate increases.

Use of POU devices was not considered in this estimate as it represents a site-specific decision which is not recommended at a master planning stage. This estimate assumes that existing POEs are maintained and combining POEs within an existing system is not performed. This evaluation, again, is a site specific decision that must be considered in more detail before implementation. The list of POEs where combining multiple POEs to form a new treatment plant site is discussed subsequently. Similarly, blending as a compliance option is not considered in the cost estimate as it is a utility specific decision based on preference and other factors.

Table 5.5 summarizes the technology type that was selected, by system size using the combined lowest cost and feasibility approach. It can be seen from the table that for systems with average population less than 300, POU devices are the lowest cost treatment technologies. For systems with average population less than 500, the most favorable treatment technologies were found to be 3a (two column Fe-AA) and 4a (two column granular iron media). For systems with average population greater than 500 and not exceeding 3,300, the most favorable treatment technology was also found to be 3a and 4a. For systems with average population greater than 3,300 and not exceeding 10,000, the most favorable technologies were also 3a and 4a. For the second lowest cost options, the use of granular iron media instead of Fe-AA media with pH adjustment was considered favorable for the majority of systems.

Table 5.5: Summary of Most Feasible Options and Lowest Treatment Costs

Treatment Technology	Systems serving average population		
	upto 500	>500-3,300	>3,300-10,000
1a	31	32	27
1b	13	10	2
2a	22	2	2
2b	5	2	1
3a	137	79	48
3b	17	15	7
3c	0	0	0
3d	2	4	2
4a	2	3	2
4b	2	2	0
4c	0	0	0
4d	0	0	0
5a	0	2	0
5b	0	0	0
Total No. of Impacted POEs	231	151	91
Total Lowest Capital Costs	\$39,090,720	\$43,417,039	\$27,226,870

5.3.1 Combined Treatment and Blending Considerations

The list of systems and associated POEs that should further consider combined treatment of multiple wells or blending with another source is presented in Table 5.6. These are POEs that are within 1-mile of another POE in the same system and which may be able to construct a new pipeline to combine the POEs to form a treatment plant or blend without treatment. These should be further evaluated on a site-specific basis. Additional cost savings may be possible and the costs shown in Table 5.6 for these POEs may be further reduced if these non-treatment options are considered.

5.3.2 POU Considerations

The list of systems and associated POEs that should further consider POU treatment is presented in Table 5.7. These are systems that serve fewer than 300 persons and significant cost savings may be incurred by using POU devices instead of centralized treatment. These should be further evaluated on a site-specific basis given the political and logistic issues associated with POU treatment.

5.4 SUMMARY

The feasibility and cost assessments that were performed indicate that the total capital cost to treat the 473 POEs serving Arizona's small water systems is \$109,700,000, not including engineering fees. The annual O&M cost for the lowest cost option is \$14,200,000. The annual O&M cost for the second lowest cost option is \$23,800,000. If engineering fees are also considered, the total project capital costs are \$142,610,000.

Use of Fe-AA with pH adjustment generally was the lowest cost option while use of granular iron media without pH adjustment was generally the second lowest cost option. Since most impacted POEs were smaller than 1 MGD, CF technology and partial stream treatment were used only to a limited extent. The trade off between lower capital costs and increased O&M costs (for increased media costs) must be considered in selecting the most appropriate option. For the AMP, it is recommended that the lowest and the second lowest options be considered.